Section six

POSSIBLE IMPACT OF CLIMATE CHANGE EFFECTS ON THE INSTALLATION

GrEnFIn: Greening Energy Market and Finance

Project objectives

FRAMEWORK

The project is focused on building a solar plant in Bologna (1MW over 1ha area).

TASK

Analyze the impact on the solar installation of the chosen climate change effects.

RESULT

Climate change impacts that have not been discarded were carefully analyzed for their impact on the installation.
The results describe how the effects of climate change will affect the installation.

Introduction

Climate change affects all regions around the world. Polar ice shields are melting and the sea is rising. In some regions extreme weather events and rainfall are becoming more common while others are experiencing more extreme heat waves and droughts.

EFFECT ON THE INSTALLATION

Climate change will have both positive and negative effects on the solar energy and its production. It might pose to be excellent for the solar power, but for the solar providers, it requires constant innovation and higher production.

FACTORS IMPACTING

In this presentation, we will discuss the main factors of climate change affecting the installation: air pollution, change of air temperature, clouds, rain and storms as well as mentioning other influences.

AIR POLLUTION

PARTICULATES

The amount of sunlight that reaches Earth's surface fluctuates over time due to the presence of particulate matters like dust or ash.

The grime that’s built up on solar panels consists of 92% of dust and 8% of pollutants created by human activity, these latter particles are those that actually block sunlight much more efficiently than natural dust does.

CASE OF BOLOGNA

Our panels are meant to be put in the outskirts of the city and not in urban areas, where these particulates are mostly concentrated.

According to the World Air Quality Index, Italy is one of the worst countries in terms of air quality conditions. One of the most affected areas is the Pianura Padana, where we find Bologna.

AIR POLLUTION

EFFECT ON SOLAR PANELS

Air pollution has a twofold effect on the solar panel: it damages the well-functioning of it over time but mostly importantly, it negatively affects the energy generation capabilities of the installed solar projects.

CLEANING

Cleaning solar panels frequently would fight the effects of air pollution and solve this problem. The problem is that the more often they’re cleaned, the more likely they are to be damaged.

AIR TEMPERATURE CHANGE

Air temperature increase of 1-1.5°C for both minimum and maximum temperature for Bologna for the period 2021-2050, compared to 1961-1990.

	Inverno	Primavera	Estate	Autunno
Tmin 2021 2050	1.2°C	1.6°C	2.5°C	1.7°C
Tmax 2021 2050	1.5°C	2.1°C	2.5°C	2°C
Tmin 2071-2099	2.8°C	3.7°C	5.5°C	3.4°C
Tmax 2071 2099	3°C	4.1°C	5.5°C	4°C

Tab. 3. Proiezioni di cambiamento climatico stagionale (EM) nella Tmin e Tmax, periodi 2021-2050 e 2071-2099, scenario A1B, Bologna.

IMPACTS ON THE PV PLANT:

1. Reduced efficiency, i.e. less power output
2. Lower capacity of underground conductors and increased soil temperature

IMPACTS ON THE PV PLANT (cont.):

3. Material damage to the equipment:
   - long exposure to heat fastens the wearing out of the PV panels.
   - panels break, in connection to extreme weather events such as heat waves over short time peaks.

WHY DOES HIGH TEMPERATURE CAUSE LOWER EFFICIENCY?

While increased insolation augments the power generated by the PV panels, the opposite happens as temperature increases.

A high air temperature causes the voltage to drop and consequently the decline of power produced by the PV.

Generally this efficiency loss is of 0.5% every 1°C, with variations across manufacturers and technologies.

AIR TEMPERATURE CHANGE

A key parameter is the temperature coefficient P_{max} : it is specific to each PV panel model and captures the change in power as temperature changes.

Example: PV plant generates 1MW at 25°C.

For the PV model SunPower Maxeon 3, the temperature coefficient is P_{max} = -0.29% /°C.

If +1°C from 25°C, the solar panel power will drop by 0.29% of its nominal power (vice versa: it rises, if the temperature drops by 1°C).

Relationship between the power and the temperature:

$$P = P_{initial} - 0.29\% * P_{initial} * \Delta T$$

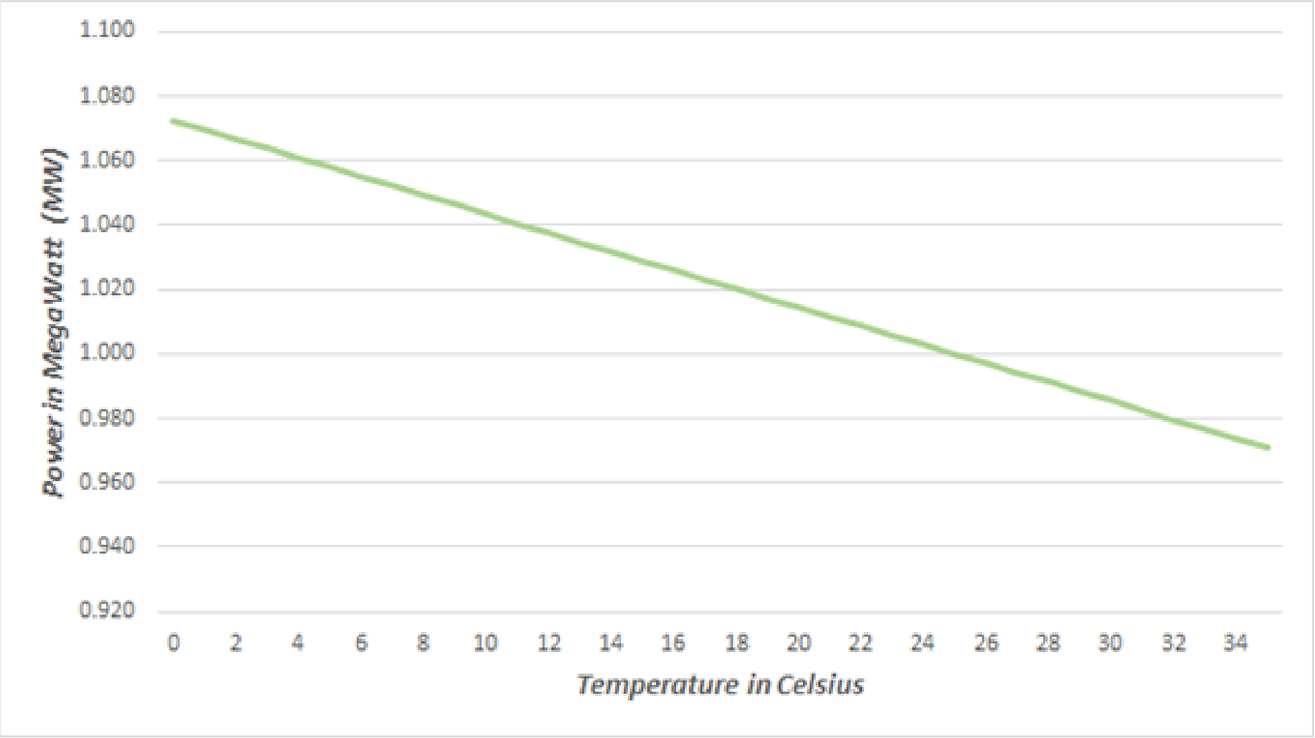
$$\Leftrightarrow P = P_{initial} * (1 - 0.0029 * (Current\ Temp - 25°C))$$

Air temperature change

In Bologna, over the year, the temperature generally ranges from 0°C to 35°C.
So, the power of the PV plant ranges from 1.0725 MW for an extremely cold (but sunny) day to 0.971 MW for a 35°C summer day.

Potential factors attenuating the impact of increased temperature:

- cooling solutions with natural or forced air flows (liquid coolants)
- green installations (like roofs) next to the plant.



Storms

While exact probabilities of occurrence are unknowable, hailstorms, extremely strong winds and especially thunderstorms can be expected to become more likely and more intense in the next 20-50 years in northern Italy. With an expected lifetime of 20-30 years even potentially rare events need to be considered.

Direct hits from lightning can cause great damage to any wiring and supportive electronics, however with sufficient grounding and redirecting the likelihood of actual damage is greatly reduced.

Regular hail (diameter<2cm) usually causes no damage, depending on built quality up to a diameter of 4m can be withstood with minor damage.

Wind speeds of up to 257 kmh have been withstood by solar power plants in previous Hurricanes in the US and in experiments in wind tunnels, however flying debris such as rocks are highly destructive.

RAINFALL AND CLOUDS

An increase in extreme weather conditions, due to climate change, is expected to impact the frequency and intensity of rainfall and cloud coverage.

The increased incidence of rainfall in a year can affect the time required to finish outdoor construction projects such as solar panel construction/fittings. Heavy rain can also impact the soil and foundation for which the panels are mounted on.

Increased rainfall also lowers the overall solar generation – photovoltaic panels generate between 10-25% of their optimal capacity during cloudy or rainy days.

Increased rainfall combined with increased surface heating can result in the greenhouse effect, which can be exacerbated in areas with higher humidity. This effect can reduce the solar penetration rates thus reducing the capacity of the solar panels.

RAINFALL AND CLOUDS

Acid rain can accelerate the corrosion of solar panels. This can lower their efficiency and panels might need to be replaced before their estimated useful life.

We are also expecting to see an increase in the incidence of hailstorms. Large hailstones can damage the outer glass of the solar panel, reducing the capacity of that panel. Hailstones can also cause micro-cracks inside the panel.

These issues can increase projected maintenance costs post-installation. If projected maintenance costs outweigh projected gains, then this could hinder decisions to install these panels at a given location.

A potential positive side of increased rainfall is that this can increase the effect of natural cleaning/removal of dust from the solar panels to allow the panels to absorb more sun rays, making them more effective.

IMPACTS ON SOLAR PANEL INSTALLATION

A word of summary

AIR TEMPERATURE CHANGE

High temperature of the air impacts the power produced by the solar panels, mainly decreasing the effectivness.
Colder day may give around 1,0725 MW and sunny day gives 0,971 MW.

RAINFALL AND CLOUDS

Rainfalls may affect the solar panel performance in many ways, i.e. construction time and costs, greenhouse effect.
Cloudy and rainy days may also increase solar panel performance.

AIR POLLUTION

Air pollution causes the solar panel to underperform. Cleaning the pollution also damages the panels.
The gases that cause the pollution are mainly due to human activity, but nature itself also can be a major interaction of the performance, i.e. birds or rain.

STORMS

We can expect extremely strong winds and thunderstorms in near future. Any direct hits from lightning can cause damage to the electronical wiring. Solar panels need to be grounded for protection. Panels are protected from some winds, but their incrising severity may be damaging.

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Created and presented by:

ANNALISA LANZOLLA

University of Bologna

ASMUND JENSSEN

Birkbeck, University of London

HENRY KLEINEIDAM

LMU in Munich

KAROLINA KACZKOWSKA

University of Economics in Katowice

MADDALENA LAMURA

Vienna University of Economics and Business

OTHMANE LARSI

Dauphine University Paris

TIMOTHY BIRABI

Birkbeck, University of London